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A METHOD OF CONSTRUCTING A STRUCTURED DATABASE OF THE TYPICAL OBJECTS OF PROTECTION ON THE BASIS OF CLUSTER ANALYSIS

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Abstract

The article discusses the possibility of constructing a structured database of the typical objects of protection. These are the objects, the occurrence of an emergency situation or fire on which leads to substantial material damage or harm to the health or loss of life of people. This problem is solved on the example of developing the methods of selection of typical objects using the cluster analysis procedures for testing the algorithms of extinguishing possible fires on the protected territory in the area of the fire department operation. The authors analyze the objects of protection on the example of one of the districts of the city of St. Petersburg; typical objects are selected, and the justification of these choices is provided.

Keywords: *Cluster Analysis, Characteristic Of The Object, Data Segmentation, Applied Social Research, Software For The Statistical Research.*

INTRODUCTION

The effectiveness of fire-fighting operations for complex objects of various functionality is largely determined by the head of emergency response and fire-fighting (HERFF) having a specific plan of actions, which takes into account various characteristics of the object of fire-fighting. It is also determined by the conditions in which the personnel of the fire-fighting team will operate, as well as the readiness (training level) of the personnel, including in relation to the given type of object. The problem of research – methodological support of personnel effective actions requires the development of a structured database of objects, the occurrence of an emergency situation or fire on which will lead to substantial material damage or harm to the health or loss of life of people. Achieving this goal involves the development of methods of selection of typical objects using the cluster analysis procedures for testing the algorithms for extinguishing possible fires on the protected territory in the area of the fire department operation. The performance of the formulated tasks will greatly expand the possibilities of practical use of decision-making methods to ensure the required effectiveness of fire extinguishing.

The main restriction accepted in the study is focusing on the consideration of housing facilities, without considering production facilities under the protection of own forces. In this case, it is assumed that there should not be many such objects, but, at the same time, they should give the necessary information as much as possible for familiarizing with the largest number of typical objects.

Certain aspects related to the preparation, support and implementation of fire extinguishing activities have been studied for a long time and are considered by many specialists. The issues of formalized statement of tasks in fire extinguishing have been considered from various points of view in the work of N.M. Zhuravlev and A.N. Denisov [1], the issues of managerial decision-making during fire extinguishing and their information-algorithmic support have been reflected in the works of Stankevich T.S. [2], Zakharevskaya S.N. [3], Karkin I.N. and Subachev S.V. [4]. A number of scientists are actively developing the direction related to the intellectual decision support systems – Kiper A.V., Stankevich T.S. [5], as well as the specifics of the activities of the management personnel are analyzed in detail [6-8].

The issues concerning formulating problems and making management decisions while fighting fires have been studied for a long time. From different points of view, these issues are considered in the works of the scholars such as Zhuravlev, Denisov, Stankevich, Zakharevskaya, and others [1-8].

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Note that a set of actions in the form of a plan for certain groups of buildings with similar characteristics and features (such as the number of storeys, area, the presence of hazardous and noxious substances on the territory, the concentration of people and others) has a typical character and is determined by the class of the object.

That is, making a sample of objects for the creation of a database to test various fire-fighting algorithms in a secure environment is topical for fire departments. In the selection process, it is extremely important to determine the vector of parameters that describe each object, carry out the accumulation of data significant with respect to the sample of objects and implement the procedures allowing systematizing these data for the usage while making the subsequent decisions relating to firefighting to create models of typical objects. The issues of application of simulation in the sphere of fire extinguishing have been studied by scientists: Demukh I.A., Kovalenko E.A., Linkova A.A., Korchagin A.B., Semenov A.O., Tarakanov D.V., Kuznetsov A.N. [9-11]. The work of Stankevich T.S. [12] contains the results of the analysis of the world and domestic market of software intended for HERFF. The study of simulation in the area of firefighting was carried out by the scientists such as Karkin, Subachev, Semenov, Tarakanov, and Kuznetsov [9-12].

The solution to this problem is reduced to the development of a methodology allowing determining the similarity-difference of objects based on a specific set of attributes and structuring the obtained data into a system. For this purpose, the authors use the cluster analysis apparatus. Cluster analysis is a multidimensional statistical procedure that performs collection of the data containing information on a sample of objects and then arranges the objects in relatively homogeneous groups [13]. As the study database, we chose a subject of the Russian Federation, the city of Saint Petersburg, and the Kirovsky District municipality.

This district is located in the south-west of St. Petersburg. Its western boundary goes along the coast of the Gulf of Finland. The housing stock is diverse and includes all categories of houses, ranging from the pre-war ones up to 10 storeys in height to the modern brick or block multistorey houses.

In the district, there are more than 60 industrial enterprises, 19 construction companies, more than 30 transport companies, five research and design organizations, three higher education institutions and nearly 16,000 small businesses and entrepreneurs. All these are representatives of a large variety of objects having differences in terms of both planning and the characteristics of structure and content of the object. In this sense, the selected district fully characterizes the diversity of objects specific for a small city or any district of a megalopolis.

According to the data of the Department of Supervisory Activities in the Kirovsky District of the Ministry of Emergency Situations of Russia in the Leningrad Region, the following objects are located in the district (Table 1):

Table 1. Objects of protection of the Kirovsky District of the city of Saint Petersburg

#	Objects	Number
1	Residential buildings	1,700
2	Outpatient clinics	14
3	Hospitals	2
4	Preschool educational establishments	71
5	Secondary schools	58
6	Scientific research institutions	1
7	Markets	5
8	Hotels	4
9	Central heating and power plants	2
10	Shopping and recreation centers	10
11	Objects of culture and art	7
	Total: 1,874	

We can learn from the above table the number of the main objects of the district and the difference between their functionality; we can conventionally divide them into separate groups of typical objects. This is the first and easiest step toward subdividing the objects into clusters based on the functional purpose of objects.

Many may say that there are no absolutely identical objects, and each has its own characteristics, even if these objects are typical. For example, each school is a unique object, as it has unique:

1. Classes equipped atypically.
2. Changes in planning.
3. Broken hydrants or not properly prepared ponds.
4. The human factor which is the cause of not timely or failed evacuation.
5. The presence and the number of people staying in school.

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However, knowing the basic characteristics of the object, one can influence the efficiency of fire-fighting to a considerable degree. Here is an example of solution based on such a priori knowledge: creating objects which have the basic and most important features of the characteristics peculiar to such objects.

As a rule, public buildings such as educational institutions, theaters, hospitals are built in a certain typical way related to their purpose. It can be concluded that the most effective form of training the personnel to extinguish fire in such objects is to create one or two buildings of such type, where they can familiarize themselves with the specificity of planning, possible substances and materials contained in them. Also, non-standard algorithms of training can be developed, with the addition of elements that are relevant to particular cases. And this can be done for every typical object of protection.

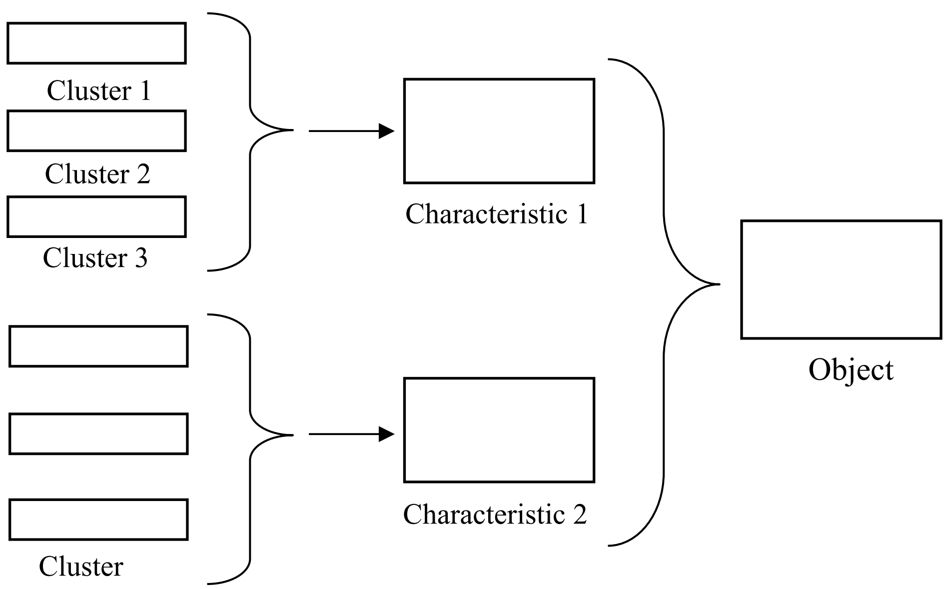

Figure 1. A simplified example of the cluster analysis procedure.

For a more accurate selection of typical objects, we need to use the most complete vector of significant characteristics, with respect to which we will compare objects and assign them to a particular cluster.

The task of the method is as follows: based on the data contained in a certain set (in this case, in the table of characteristics of objects), we need to partition the set of objects (buildings) into a number of clusters (subgroups), so that each object belongs to only one cluster and that the objects belonging to the same cluster are similar and the objects from different clusters are different (Figure 1) [14].

In order to determine the similarity of objects, one should use some unit of measurement (a similarity measure). The most obvious and widely used method is to use the distance between the objects in the space of measured parameters as such measure. The objects with smaller distance between them are more similar than the objects with larger distance. However, there are several ways to calculate this distance. The most widely used is the Euclidean distance, defined as

$$dij = \sqrt{\sum_{k=1}^{p}(xik - xjk)^2},$$

where dij is the distance between the objects i and j, whereas xik is the value of the k-th variable for the i-th object. There are other kinds of distance, for example, the Manhattan distance (or the city-block distance):

$$dij = \sum_{k=1}^{p}|xik - xjk|,$$

or the Chebyshev distance (supremum norm), the maximum absolute difference in the values for any variable:

$$dij = \sup\{|xki - xkj|\}, k = 1,2, \dots p.$$

When using distance as a similarity measure, it is often required to normalize the variables to the zero mean and the unit variance, because the variables with large absolute values may suppress the influence of the variables with low values. Further complications arise when the

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variables are binary in nature. This situation requires the use of associativity coefficients as a similarity measure. In our case, when the data are mixed in nature (quantitative, ordinal and dichotomous), we need to use the Gower coefficient (named by its author) to form a similarity matrix:

$$sij = \frac{\sum_{k=1}^{p} Sijk}{\sum_{k=1}^{p} Wijk},$$

where *Wijk* is a weight variable, which assumes the value 1 if the comparison of objects with respect to characteristic *k* should be taken into account, and 0, otherwise; *Sijk* is the "contribution" into the similarity of the objects, depending on whether the characteristic *k* is taken into account in the comparison of objects *i* and *j* [15].

For the binary data, *Sij* is obtained according to the following system of calculation (Table 2):

Table 2. Calculation of the Gower coefficient.

Object *i*	1	1	0	0
Object *j*	1	0	1	0
Contribution *Sijk*	1	0	0	0
Weight *Wijk*	1	1	1	0

For the ordinal data, *Sijk* is 1 if the compared values are equal and 0 if not.

For the quantitative data, we have the equation $Sijk = 1 - |xik - xjk|/Rk$, where xik is the value of the *k*-th variable for object i, whereas *Rk* is the range of values of this variable.

The next step in the cluster analysis after selecting the similarity measure is to choose a clustering method. Presently, the developed clustering methods form seven families [16]:

1. Hierarchical agglomerative methods;
2. Hierarchical division methods;
3. Iterative methods of grouping;
4. Methods of searching the modal values of density;
5. Factor methods;
6. Methods of concentrations;
7. Methods using the graph theory.

In social problems, the most commonly used are the hierarchical agglomerative methods. These methods browse the similarity matrix and successively unite similar objects. As a result, we obtain a single cluster combining all the objects under consideration. An important advantage of the hierarchical methods is the possibility of representing the process of unification as a tree diagram (dendrogram) and subsequent selecting the degree of similarity to obtain the desired number of clusters. Among them are the method of single links, the method of middle links, the method of complete links, Ward's method, and others. The use of different methods may lead to different results of partition.

In our case, we use Ward's method, the specificity of which is the tendency to partition into clusters of similar size. The method optimizes the minimum variance within clusters. The objective function is the sum of squared deviations (SSD):

SSD= $x_j^2 - 1/n\left(\sum x_j^2\right)$, where xj is the value of the characteristic of the *j*-th object.

The data processing consists in the integration of clusters in such a way as to cause minimal increase in their intragroup standard deviation (SD). In the first step, all clusters are composed of one object and their SD = 0. Further, the number of clusters successively decreases, and, as a result, all objects are combined into a single cluster.

As a result, the following parameters were considered as the characteristics of objects (Table 3):

1. Height of the buildings. One of the basic characteristics, which allows determining the need to work at height associated with a number of specific complications of working conditions (Table 3) [17].

Table 3. Height of the buildings.

Type of object	Height
Residential buildings	≤ 75
Public buildings for administrative purpose	≤ 50
Cultural and entertainment buildings	≤ 8
Industrial buildings	≤ 54

2. Number of people. This is a significant characteristic that gives information concerning the need to take further decisions to evacuate and rescue the victims (Table 4) [18].

Table 4. Number of people.

Name	Number of people
Small	≤ 50
Mass	50 and more

3. The functional purpose of the buildings. It allows determining the original specificity of the object; for example, a school building or similar educational institution, kindergarten or any other establishment having its own features of planning (Table 5) [19].

Table 5. Functional Purpose Of The Buildings.

Name	Description
F1	The buildings designed for permanent residence or temporary stay of people
F2	Buildings for the entertainment and cultural-educational institutions
F3	Buildings for public services
F4	Buildings for scientific and educational institutions, scientific and design organizations, government bodies
F5	Buildings for manufacturing or storage purposes

4. Area, this parameter allows determining the number of personnel and equipment needed to extinguish the fire. Up to 1,500 m^2 and above.

5. The presence of explosive substances and materials. This feature allows finding a way to extinguish fire (the use of water or other fire extinguishing agents).

6. Close availability of a hydrant or pond. It is necessary to address the issue of uninterrupted supply of water, which directly affects the time of fire extinguishing.

Based on the above, a primary database is formed, a short form of which can be represented by a summary table (Table 6):

Table 6. A Summary Of The Objects Of Protection Of The Kirovsky District Of St. Petersburg.

N	Type of object	Height, m	Number of people	Funct. purpose	Area	Explosive substances	Close availability of a hydrant or pond
1	Residential buildings	≤ 75	50 and more	F1	up to 1,500 m^2	no	yes
2	Schools	50≤	50 and more	F1	up to 1,500 m^2	no	yes
3	Kindergartens	≤ 50	less than 50	F1	above 1,500 m^2	no	yes
4	Residential buildings	≤ 75	50 and more	F1	up to 1,500 m^2	yes	no
5	Outpatient clinics	≤ 50	50 and more	F3	above 1,500 m^2	no	yes
6	Shopping and recreation centers	≤ 50	50 and more	F3	above 1,500 m^2	yes	no
7	Kindergartens	50≤	50 and more	F1	above 1,500 m^2	no	yes
8	Residential buildings	75≤	50 and more	F1	above 1,500 m^2	no	yes
…	…	…	…	…	…	…	…
N	(Residential buildings, …)	(from 5< to 75<)	(less than 50; 50 and more	(FN)	(up to/above 1,500 m^2)	(yes/no)	(yes/no)

It should be noted that the vectors of the described objects can be more complete and reflect a variety of characteristics.

The simplest tool for the cluster analysis of the data of our study is the SPSSStatistics 17.0 software (Figure 2) [20], which allows maximally rapidly carrying out the clustering of objects (observations) according to the specified characteristics: this is mainly due to simplicity of the interface, which is similar in many respects to the Microsoft Excel software product. Currently, the SPSSStatistics software package is one of the market leaders in the field of commercial statistical products intended for applied research in the social sciences.

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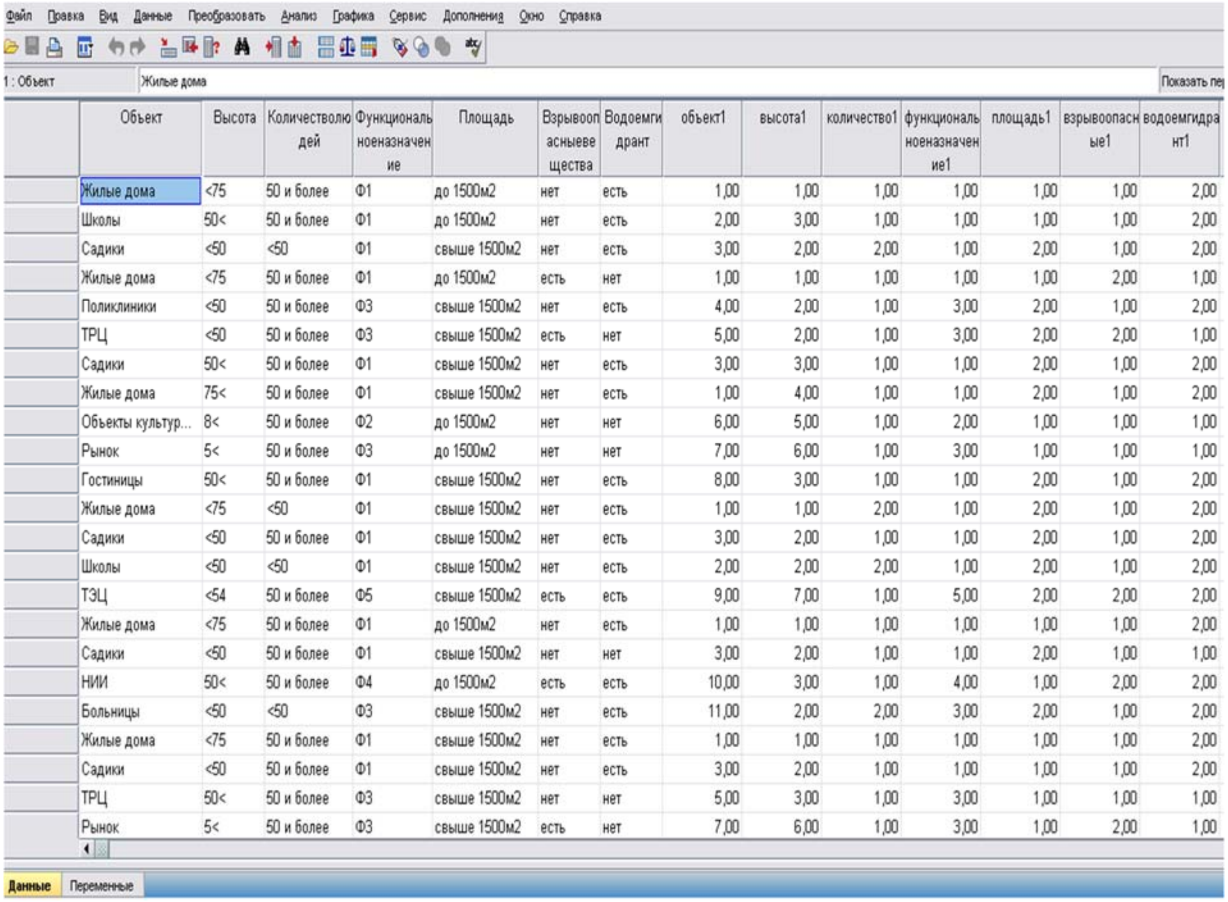

Объект	Высота	Количестволюдей	Функциональноеназначение	Площадь	Взрывоопасныевещества	Водоемгидрант	объект1	высота1	количество1	функциональноеназначение1	площадь1	взрывоопасные1	водоемгидрант1
Жилые дома	<75	50 и более	Ф1	до 1500м2	нет	есть	1,00	1,00	1,00	1,00	1,00	1,00	2,00
Школы	50<	50 и более	Ф1	до 1500м2	нет	есть	2,00	3,00	1,00	1,00	1,00	1,00	2,00
Садики	<50	<50	Ф1	свыше 1500м2	нет	есть	3,00	2,00	2,00	1,00	2,00	1,00	2,00
Жилые дома	<75	50 и более	Ф1	до 1500м2	есть	нет	1,00	1,00	1,00	1,00	1,00	2,00	1,00
Поликлиники	<50	50 и более	Ф3	свыше 1500м2	нет	есть	4,00	2,00	1,00	3,00	2,00	1,00	2,00
ТРЦ	<50	50 и более	Ф3	свыше 1500м2	есть	нет	5,00	2,00	1,00	3,00	2,00	2,00	1,00
Садики	50<	50 и более	Ф1	свыше 1500м2	нет	есть	3,00	3,00	1,00	1,00	2,00	1,00	2,00
Жилые дома	75<	50 и более	Ф1	свыше 1500м2	нет	есть	1,00	4,00	1,00	1,00	2,00	1,00	2,00
Объекты культур...	8<	50 и более	Ф2	до 1500м2	нет	нет	6,00	5,00	1,00	2,00	1,00	1,00	1,00
Рынок	5<	50 и более	Ф3	до 1500м2	нет	нет	7,00	6,00	1,00	3,00	1,00	1,00	1,00
Гостиницы	50<	50 и более	Ф1	свыше 1500м2	нет	есть	8,00	3,00	1,00	1,00	2,00	1,00	2,00
Жилые дома	<75	<50	Ф1	свыше 1500м2	нет	есть	1,00	1,00	2,00	1,00	2,00	1,00	2,00
Садики	<50	50 и более	Ф1	свыше 1500м2	нет	есть	3,00	2,00	1,00	1,00	2,00	1,00	2,00
Школы	<50	<50	Ф1	свыше 1500м2	нет	есть	2,00	2,00	2,00	1,00	2,00	1,00	2,00
ТЭЦ	<54	50 и более	Ф5	свыше 1500м2	есть	есть	9,00	7,00	1,00	5,00	2,00	2,00	2,00
Жилые дома	<75	50 и более	Ф1	до 1500м2	нет	есть	1,00	1,00	1,00	1,00	1,00	1,00	2,00
Садики	<50	50 и более	Ф1	свыше 1500м2	нет	нет	3,00	2,00	1,00	1,00	2,00	1,00	1,00
НИИ	50<	50 и более	Ф4	до 1500м2	есть	есть	10,00	3,00	1,00	4,00	1,00	2,00	2,00
Больницы	<50	<50	Ф3	свыше 1500м2	нет	есть	11,00	2,00	2,00	3,00	2,00	1,00	2,00
Жилые дома	<75	50 и более	Ф1	свыше 1500м2	нет	есть	1,00	1,00	1,00	1,00	1,00	1,00	2,00
Садики	<50	50 и более	Ф1	свыше 1500м2	нет	есть	3,00	2,00	1,00	1,00	1,00	1,00	2,00
ТРЦ	50<	50 и более	Ф3	свыше 1500м2	нет	нет	5,00	3,00	1,00	3,00	1,00	1,00	1,00
Рынок	5<	50 и более	Ф3	свыше 1500м2	есть	нет	7,00	6,00	1,00	3,00	1,00	2,00	1,00

Figure 2. Interface Of The Spssstatistics 17.0 Program.

As a result of the conducted cluster analysis of a sample of objects from among 1,857 objects of protection of the Kirovsky District of St. Petersburg, we obtained the following dendrogram showing a partition of objects into clusters (Figure 3, the dendrogram):

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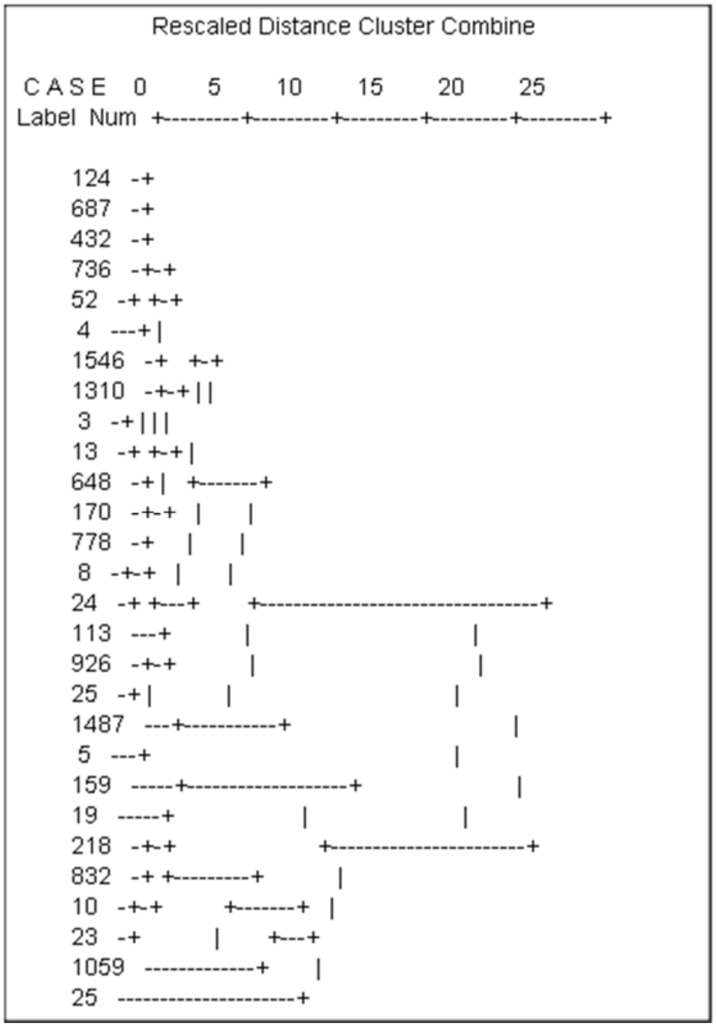

Figure 3. The Dendrogram "Clusters Of Typical Objects Of Protection".

As a result, based on the value of the objective function, four clusters have been allocated:

1. The first cluster is the largest one and is represented mainly by residential buildings up to 75 meters in height, with the area of over 1,500 square meters, with the presence of nearby fire hydrants or ponds, as well as with a large number of people requiring evacuation in case of fire. Also, a specific feature of the objects of this cluster is the lack of dangerous substances in their territory.

2. The second cluster consists of pre-school and secondary educational institutions, as well as hotels of the height of up to 20 meters, mostly with the area of over 1,500 square meters, which are located in close proximity to fire hydrants or ponds, as well as with a small probability of the presence of dangerous substances in the territory.

3. The third cluster is formed by the cultural facilities and covered markets up to 20 meters high, covering an area of less than 1,500 square meters, most of which are not located in close proximity to fire hydrants or ponds. These facilities require evacuation of people from their territory.

4. The final, the fourth cluster is represented by medical institutions (outpatient clinics and hospitals) up to 30 meters high, having dangerous substances in their territory, located in the immediate vicinity of fire hydrants and ponds, as well as requiring evacuation of large numbers of people.

It should be noted that, by choosing the threshold value of the objective function, we can increase or decrease the accuracy of the typical object's representation of its cluster. Making our choice rougher minimizes the number of clusters and, consequently, the number of typical objects required for simulation, which is important in the conditions of limited resources. At the same time, it reduces the accuracy of representation of a real set of objects.

CONCLUSION.

The results obtained in research allow rightfully arguing that the solution of the task of developing the research-methodical framework of the formation of a structured database of typical objects of protection makes it possible to take into account various features of an object on fire, the conditions, in which the personnel of the fire department will work, and also the readiness (level of training) of the personnel, and to effectively work out various algorithms for fire extinguishing. The directions of further research are as follows: the expansion of the types of studied objects and the number of parameters that are both quantitative and qualitative in nature and taken for selection in order to improve its accuracy.

CONFLICT OF INTERESTS.

We have no conflict of interest to declare.

REFERENCES:

[1] Zhuravlev, N.M., & Denisov, A.N., 2010, “Formalizatsiya i postanovka zadachi pozharnym podrazdeleniyam pri tushenii pozhara” [Formalization and Setting the Task for the Fire Brigade during Firefighting]. Tekhnologii tekhnosfernoy bezopasnosti, 2.

[2] Stankevich, T.S., 2015, “Razrabotka informatsionnoy podsistemy sistemy podderzhki prinyatiya resheniy rukovoditelya tusheniya pozhara” [Development of an Information Subsystem of the Support System for the Decision Making by the Head of Firefighting Team]. In III Baltiyskiy morskoy forum Svetlogorsk (Kaliningradskaya obl.), Kaliningrad, 24-30 maya 2015 g. [III Baltic Marine Forum, Svetlogorsk (Kaliningrad Region), Kaliningrad, May 24-30, 2015].

[3] Zakharevskaya, S.N., 2015, “Algoritm sostavleniya plana tusheniya pozhara v sisteme podderzhki prinyatiya upravlencheskikh resheniy na pozhare” [The Algorithm of Drawing up a Plan to Extinguish Fire in the Support System for the Decision Making in Firefighting]. Tekhnologii tekhnosfernoy bezopasnosti, 3.

[4] Kar’kin, I.N., & Subachev, S.V., 2012, “Ispol'zovanie rezul'tatov komp'yuternogo modelirovaniya dlya sostavleniya planov tusheniya pozharov zdaniy i sooruzheniy” [The Use of Computer Simulation Results to Produce the Plans of Fighting Fires in Buildings and Structures]. Monitoring. Nauka i bezopasnost', 3.

[5] Kiper, A.V., & Stankevich, T.S., 2014, “Algoritmicheskoe obespechenie intellektual'noy sistemy podderzhki prinyatiya resheniy, prednaznachennoy dlya rukovoditelya tusheniya pozhara” [Algorithmic Support of an Intelligent System for the Support of the Decision Making by the Head of Firefighting Team]. Pozharovzryvobezopasnost', 9.

[6] Solodilov, D.A., 2013, “Analiz soderzhaniya protsessa prinyatiya upravlencheskikh resheniy rukovoditelem tusheniya pozhara” [Analysis of the Content of the Management Decision-Making Process by the Head of Firefighting]. In Konferentsiya “Sovremennye tekhnologii obespecheniya grazhdanskoy oborony i likvidatsii posledstviy chrezvychaynykh situatsiy”, Voronezh, 19 aprelya 2013 g. [Conference “Modern Technologies for Ensuring Civil Defense and Relieving the Consequences of the Emergency Situations”, Voronezh, April 19, 2013].

[7] Ermilov, A.V., 2015, “Deyatel'nost' rukovoditelya tusheniya pozhara kak pedagogicheskaya problema” [Activity of the Head of a Firefighting Team as a Pedagogical Problem]. Prioritetnye napravleniya razvitiya nauki i obrazovaniya, 2.

[8] Terebnyov, V.V., Semyonov, A.O., & Burkov, I.V., 2006, “Printsipy upravleniya tusheniem pozhara” [The Principles of Firefighting Management]. Pozharovzryvobezopasnost', 6.

[9] Demukh, I.A., Kovalenko, E.A., Lin’kova, A.A., & Korchagin, A.B., 2013, “Modelirovanie deystviy pri tushenii pozhara” [Modeling of Action in Extinguishing Fire]. Rossiya molodaya: peredovye tekhnologii – v promyshlennost', 3.

[10] Semyonov, A.O., & Tarakanov, D.V., 2011, “Algoritm mnogokriterial'nogo vybora variantov rasstanovki sil i sredstv pri tushenii pozharov s primeneniem imitatsionnogo modelirovaniya” [The Algorithm of Multicriteria Choice of the Alignment of Forces and Means in Firefighting Using Simulation]. Tekhnologii tekhnosfernoy bezopasnosti, 4.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[11] Kuznetsov, A.N., 2014, “Effektivnost' ispol'zovaniya matematicheskogo modelirovaniya v tushenii i rassledovanii pozharov” [The Effectiveness of Using Mathematical Modeling in the Extinguishing and Investigating Fires]. In Konferentsiya “Ekonomika i sotsium: problemy i perspektivy vzaimodeystviya”, Saratov, 28 fevralya 2014 g. [Conference “Economy and Society: Challenges and Prospects for Cooperation”, Saratov, February 28, 2014].

[12] Stankevich, T.S., 2014, “Analiz mirovogo i otechestvennogo rynka programmnykh sredstv, prednaznachennykh dlya rukovoditelya tusheniya pozhara” [Analysis of the World and Domestic Market for the Software Intended for the Head of Firefighting]. Bezopasnost' zhiznedeyatel'nosti, 7.

[13] Ayvazyan, S.A., Bukhshtaber, V.M., Enyukov, I.S., & Meshalkin, L.D., 1989, “Prikladnaya statistika: Klassifikatsiya i snizhenie razmernosti” [Applied Statistics: Classification and Reduction of Dimension]. Moscow: Finansy i statistika.

[14] Durand, B., & Odell, P., 1977, “Klasternyy analiz” [Cluster Analysis]. Moscow: Statistika.

[15] Gaydyshev, I., 2001, “Analiz i obrabotka dannykh: spetsial'nyy spravochnik” [Analysis and Processing of Data: Special Directory]. St. Petersburg: Piter.

[16] Kim, J.O., Mueller, C.W., Klekka, W.R. et al., 1989, “Faktornyy, diskriminantnyy i klasternyy analiz” [Factor, Discriminant and Cluster Analysis]. Moscow: Finansy i statistika.

[17] SP 2.13130.2009. “Obespechenie ognestoykosti ob"ektov zashchity” [SP 2.13130.2009. Guaranteeing the Fire Resistance of the Objects of Protection]. (2009).

[18] Postanovlenie Pravitel'stva RF ot 25 aprelya 2012 goda No. 390 “O protivopozharnom rezhime” [Government Decree No. 390 “On the Fire-Protection Regime”]. (2012, April 25).

[19] Federal'nyy zakon RF ot 22 iyulya 2008 goda No. 123-FZ “Tekhnicheskiy reglament o trebovaniyakh pozharnoy bezopasnosti” (s izmeneniyami i dopolneniyami) [Federal Law No. 123-FZ “Technical Regulations on the Fire Safety Requirements” (as amended)]. (2008, July 22).

[20] SPSS. (n.d.). Wikipedia. Retrieved December 16, 2016, from http://ru.wikipedia.org/wiki/SPSS.